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C.3 Electric Power Research Institute (EPRI), "Probabilistic Seismic Hazard Evaluations at Nuclear Power Plant Sites in the Central and Eastern United States," NP-4726, All Volumes, 1989-1991.

[1] Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-1800); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161; <http://www.ntis.gov/ordernow>; telephone (703)487-4650. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; email is PDR@NRC.GOV.

[2] Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike (first floor), Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or 1-(800)397-4209; fax (301)415-3548; e-mail <PDR@NRC.GOV>.

APPENDIX D
GEOLOGICAL, SEISMOLOGICAL, AND GEOPHYSICAL INVESTIGATIONS TO CHARACTERIZE SEISMIC SOURCES

D.1 INTRODUCTION

As characterized for use in probabilistic seismic hazard analyses (PSHA), seismic sources are zones within which future earthquakes are likely to occur at the same recurrence rates. Geological, seismological, and geophysical investigations provide the information needed to identify and characterize source parameters, such as size and geometry, and to estimate earthquake recurrence rates and maximum magnitudes. The amount of data available about earthquakes and their causative sources varies substantially between the WUS (west of the Rocky Mountain front) and the Central and Eastern United States (CEUS), or stable continental region (SCR) (east of the Rocky Mountain front). Furthermore, there are variations in the amount and quality of data within these regions.

In active tectonic regions there are both capable tectonic sources and seismogenic sources, and because of their relatively high activity rate they may be more readily identified. In the CEUS, identifying seismic sources is less certain because of the difficulty in correlating earthquake activity with known tectonic structures, the lack of adequate knowledge about earthquake causes, and the relatively lower activity rate. However, several significant tectonic structures exist and some of these have been interpreted as potential seismogenic sources (e.g., the New Madrid fault zone, Nemaha Ridge, and Meers fault).

In the CEUS, there is no single recommended procedure to follow to characterize maximum magnitudes associated with such candidate seismogenic sources; therefore, it is most likely that the determination of the properties of the seismogenic source, whether it is a tectonic structure or a seismotectonic province, will be inferred rather than demonstrated by strong correlations with seismicity or geologic data. Moreover, it is not generally known what relationships exist between observed tectonic structures in a seismic source within the CEUS and the current earthquake activity that may be associated with that source. Generally, the observed tectonic structure resulted from ancient tectonic forces that are no longer present. The historical seismicity record, the results of regional and site studies, and judgment play key roles. If, on the other hand, strong correlations and data exist suggesting a relationship between seismicity and seismic sources, approaches used for more active tectonic regions can be applied.

The primary objective of geological, seismological, and geophysical investigations is to develop an up-to-date, site-specific earth science data base that supplements existing information (Ref. D.1). In the CEUS, the results of these investigations will also be used to assess whether new data and their interpretation are consistent with the information used as the basis for accepted probabilistic seismic hazard studies. If the new data are consistent with the existing earth science data base, modification of the hazard analysis is not required. For sites in the CEUS where there is significant new information (see Appendix E) provided by the site investigation, and for sites in the WUS, site-specific seismic sources are to be determined. It is anticipated that for most sites in the CEUS, new information will have been adequately bounded by existing seismic source interpretations.

The following are to be evaluated for a seismic source for site-specific source interpretations:

- Seismic source location and geometry (location and extent, both surface and subsurface). This evaluation will normally require interpretations of available geological, geophysical, and seismological data in the source region by multiple experts or a team of experts. The evaluation should include interpretations of the seismic potential of each source and relationships among seismic sources in the region in order to express uncertainty in the evaluations. Seismic source evaluations generally develop four types of sources: (1) fault-specific sources, (2) area sources representing concentrated historic seismicity not associated with known tectonic structure, (3) area sources representing geographic regions with similar tectonic histories, type of crust, and structural features, and (4) background sources. Background sources are generally used to express uncertainty in the overall seismic source configuration interpreted for the site region. Acceptable approaches for evaluating and characterizing uncertainties for input to a seismic hazard calculation are contained in NUREG/CR-6372 (Ref. D.2).

- Evaluations of earthquake recurrence for each seismic source, including recurrence rate and recurrence model. These evaluations normally draw most heavily on historical and instrumental seismicity associated with each source and paleoearthquake information. Preferred methods and approaches for evaluating and characterizing uncertainty in earthquake recurrence generally will depend on the type of source. Acceptable methods are described in NUREG/CR-6372 (Ref. D.2).

- Evaluations of the maximum earthquake magnitude for each seismic source. These evaluations will draw on a broad range of source-specific tectonic characteristics, including tectonic history and available seismicity data. Uncertainty in this evaluation should normally be expressed as a maximum magnitude distribution. Preferred methods and information for evaluating and characterizing maximum earthquakes for seismic sources vary with the type of source. Acceptable methods are contained in NUREG/CR-6372 (Ref. D.2).

- Other evaluations, depending on the geologic setting of a site, such as local faults that have a history of Quaternary (last 2 million years) displacements, sense of slip on faults, fault length and width, area of faults, age of displacements, estimated displacement per event, estimated earthquake magnitude per offset event, orientations of regional tectonic stresses with respect to faults, and the possibility of seismogenic folds. Capable tectonic sources are not always exposed at the ground surface in the WUS as demonstrated by the buried reverse causative faults of the 1983 Coalinga, 1988 Whittier Narrows, l989 Loma Prieta, and 1994 Northridge earthquakes. These examples emphasize the need to conduct thorough investigations not only at the ground surface but also in the subsurface to identify structures at seismogenic depths. Whenever faults or other structures are encountered at a site (including sites in the CEUS) in either outcrop or excavations, it is necessary to perform adequately detailed specific investigations to determine whether or not they are seismogenic or may cause surface deformation at the site. Acceptable methods for performing these investigations are contained in NUREG/CR-5503 (Ref. D.3).

- Effects of human activities such as withdrawal of fluid from or addition of fluid to the subsurface associated with mining or the construction of dams and reservoirs.

- Volcanic hazard is not addressed in this regulatory guide and will be considered on a case-by-case basis in regions where a potential for this hazard exists. For sites where volcanic hazard is evaluated, earthquake sources associated with volcanism should be evaluated and included in the seismic source interpretations input to the hazard calculation.

D.2. INVESTIGATIONS TO EVALUATE SEISMIC SOURCES

D.2.1 General

Investigations of the site and region around the site are necessary to identify both seismogenic sources and capable tectonic sources and to determine their potential for generating earthquakes and causing surface deformation. If it is determined that surface deformation need not be taken into account at the site, sufficient data to clearly justify the determination should be presented in the application for an early site permit, construction permit, operating license, or combined license. Generally, any tectonic deformation at the earth's surface within 40 km (25 miles) of the site will require detailed examination to determine its significance. Potentially active tectonic deformation within the seismogenic zone beneath a site will have to be assessed using geophysical and seismological methods to determine its significance.

Engineering solutions are generally available to mitigate the potential vibratory effects of earthquakes through design. However, engineering solutions cannot always be demonstrated to be adequate for mitigation of the effects of permanent ground displacement phenomena such as surface faulting or folding, subsidence, or ground collapse. For this reason, it is prudent to select an alternative site when the potential for permanent ground displacement exists at the proposed site (Ref. D.4).

In most of the CEUS, instrumentally located earthquakes seldom bear any relationship to geologic structures exposed at the ground surface. Possible geologically young fault displacements either do not extend to the ground surface or there is insufficient geologic material of the appropriate age available to date the faults. Capable tectonic sources are not always exposed at the ground surface in the WUS, as demonstrated by the buried (blind) reverse causative faults of the 1983 Coalinga, 1988 Whittier Narrows, 1989 Loma Prieta, and 1994 Northridge earthquakes. These factors emphasize the need to conduct thorough investigations not only at the ground surface but also in the subsurface to identify structures at seismogenic depths.

The level of detail for investigations should be governed by knowledge of the current and late Quaternary tectonic regime and the geological complexity of the site and region. The investigations should be based on increasing the amount of detailed information as they proceed from the regional level down to the site area [e.g., 320 km (200 mi) to 8 km (5 mi) distance from the site]. Whenever faults or other structures are encountered at a site (including sites in the CEUS) in either outcrop or excavations, it is necessary to perform many of the investigations described below to determine whether or not they are capable tectonic sources.

The investigations for determining seismic sources should be carried out at three levels, with areas described by radii of 320 km (200 mi), 40 km (25 mi), and 8 km (5 mi) from the site. The level of detail increases closer to the site. The specific site, to a distance of at least 1 km (0.6 mi), should be investigated in more detail than the other levels.

The regional investigations [within a radius of 320 km (200 mi) of the site] should be planned to identify seismic sources and describe the Quaternary tectonic regime. The data should be presented at a scale of 1:500,000 or smaller. The investigations are not expected to be extensive or in detail, but should include a comprehensive literature review supplemented by focused geological reconnaissances based on the results of the literature study (including topographic, geologic, aeromagnetic, and gravity maps and airphotos). Some detailed investigations at specific locations within the region may be necessary if potential capable tectonic sources or seismogenic sources that may be significant for determining the safe shutdown earthquake ground motion are identified.

The large size of the area for the regional investigations is recommended because of the possibility that all significant seismic sources, or alternative configurations, may not have been enveloped by the LLNL/EPRI data base. Thus, it will increase the chances of (1) identifying evidence for unknown seismic sources that might extend close enough for earthquake ground motions generated by that source to affect the site and (2) confirming the PSHA's data base. Furthermore, because of the relatively aseismic nature of the CEUS, the area should be large enough to include as many historical and instrumentally recorded earthquakes for analysis as reasonably possible. The specified area of study is expected to be large enough to incorporate any previously identified sources that could be analogous to sources that may underlie or be relatively close to the site. In past licensing activities for sites in the CEUS, it has often been necessary, because of the absence of datable horizons overlying bedrock, to extend investigations out many tens or hundreds of kilometers from the site along a structure or to an outlying analogous structure in order to locate overlying datable strata or unconformities so that geochronological methods could be applied. This procedure has also been used to estimate the age of an undatable seismic source in the site vicinity by relating its time of last activity to that of a similar, previously evaluated structure, or a known tectonic episode, the evidence of which may be many tens or hundreds of miles away.

In the WUS it is often necessary to extend the investigations to great distances (up to hundreds of kilometers) to characterize a major tectonic structure, such as the San Gregorio-Hosgri Fault Zone and the Juan de Fuca Subduction Zone. On the other hand, in the WUS it is not usually necessary to extend the regional investigations that far in all directions. For example, for a site such as Diablo Canyon, which is near the San Gregorio-Hosgri Fault, it would not be necessary to extend the regional investigations farther east than the dominant San Andreas Fault, which is about 75 km (45 mi) from the site; nor west beyond the Santa Lucia Banks Fault, which is about 45 km (27 mi). Justification for using lesser distances should be provided.

Reconnaissance-level investigations, which may need to be supplemented at specific locations by more detailed explorations such as geologic mapping, geophysical surveying, borings, and trenching, should be conducted to a distance of 40 km (25 mi) from the site; the data should be presented at a scale of 1:50,000 or smaller.

Detailed investigations should be carried out within a radius of 8 km (5 mi) from the site, and the resulting data should be presented at a scale of 1:5,000 or smaller. The level of investigations should be in sufficient detail to delineate the geology and the potential for tectonic deformation at or near the ground surface. The investigations should use the methods described in subsections D.2.2 and D.2.3 that are appropriate for the tectonic regime to characterize seismic sources.

The areas of investigations may be asymmetrical and may cover larger areas than those described above in regions of late Quaternary activity, regions with high rates of historical seismic activity (felt or instrumentally recorded data), or sites that are located near a capable tectonic source such as a fault zone.

Data from investigations at the site (approximately 1 km^2) should be presented at a scale of 1:500 or smaller. Important aspects of the site investigations are the excavation and logging of exploratory trenches and the mapping of the excavations for the plant structures, particularly plant structures that are characterized as Seismic Category I. In addition to geological, geophysical, and seismological investigations, detailed geotechnical engineering investigations, as described in Regulatory Guide 1.132 (Ref. D.5) and NUREG/CR-5738 (Ref. D.6), should be conducted at the site.

The investigations needed to assess the suitability of the site with respect to effects of potential ground motions and surface deformation should include determination of (1) the lithologic, stratigraphic, geomorphic, hydrologic, geotechnical, and structural geologic characteristics of the site and the area surrounding the site, including its seismicity and geological history, (2) geological evidence of fault offset or other distortion such as folding at or near ground surface within the site area (8 km radius), and (3) whether or not any faults or other tectonic structures, any part of which are within a radius of 8 km (5 mi) from the site, are capable tectonic sources. This information will be used to evaluate tectonic structures underlying the site area, whether buried or expressed at the surface, with regard to their potential for generating earthquakes and for causing surface deformation at or near the site. This part of the evaluation should also consider the possible effects caused by human activities such as withdrawal of fluid from or addition of fluid to the subsurface, extraction of minerals, or the loading effects of dams and reservoirs.

D.2.2 Reconnaissance Investigations, Literature Review, and Other Sources of Preliminary Information

Regional literature and reconnaissance-level investigations should be planned based on reviews of available documents and the results of previous investigations. Possible sources of information, in addition to refereed papers published in technical journals, include universities, consulting firms, and government agencies. The following guidance is provided but it is not considered all-inclusive. Some investigations and evaluations will not be applicable to every site, and situations may occur that require investigations that are not included in the following discussion. In addition, it is anticipated that new technologies will be available in the future that will be applicable to these investigations.

D.2.3 Detailed Site Vicinity and Site Area Investigations

The following methods are suggested but they are not all-inclusive and investigations should not be limited to them. Some procedures will not be applicable to every site, and situations will occur that require investigations that are not included in the following discussion. It is anticipated that new technologies will be available in the future that will be applicable to these investigations.

D.2.3.1 Surface Investigations

Surface exploration to assess the geology and geologic structure of the site area is dependent on the site location and may be carried out with the use of any appropriate combination of the geological, geophysical, and seismological techniques summarized in the following paragraphs. However, not all of these methods must be carried out at a given site.

D.2.3.1.1. Geological interpretations should be performed of aerial photographs and other remote-sensing as appropriate for the particular site conditions, to assist in identifying rock outcrops, faults and other tectonic features, fracture traces, geologic contacts, lineaments, soil conditions, and evidence of landslides or soil liquefaction.

D.2.3.1.2. Mapping topographic, geomorphic, and hydrologic features should be performed at scales and with contour intervals suitable for analysis and descriptions of stratigraphy (particularly Quaternary), surface tectonic structures such as fault zones, and Quaternary geomorphic features. For coastal sites or sites located near lakes or rivers, this includes topography, geomorphology (particularly mapping marine and fluvial terraces), bathymetry, geophysics (such as seismic reflection), and hydrographic surveys to the extent needed to describe the site area features.

D.2.3.1.3. Vertical crustal movements should be evaluated using: (1) geodetic land surveying and (2) geological analyses (such as analysis of regional dissection and degradation patterns), marine and lacustrine terraces and shorelines, fluvial adjustments (such as changes in stream longitudinal profiles or terraces), and other long-term changes (such as elevation changes across lava flows).

D.2.3.1.4. Analysis should be performed to determine the tectonic significance of offset, displaced, or anomalous landforms such as displaced stream channels or changes in stream profiles or the upstream migration of knick-points; abrupt changes in fluvial deposits or terraces; changes in paleo-channels across a fault; or uplifted, down-dropped, or laterally displaced marine terraces.

D.2.3.1.5. Analysis should be performed to determine the tectonic significance of Quaternary sedimentary deposits within or near tectonic zones such as fault zones, including (1) fault-related or fault-controlled deposits such as sag ponds, graben fill deposits, and colluvial wedges formed by the erosion of a fault paleo-scarp, and (2) non-fault-related, but offset, deposits such as alluvial fans, debris cones, fluvial terrace, and lake shoreline deposits.

D.2.3.1.6. Identification and analysis should be performed of deformation features caused by vibratory ground motions, including seismically induced liquefaction features (sand boils, explosion craters, lateral spreads, settlement, soil flows), mud volcanoes, landslides, rockfalls, deformed lake deposits or soil horizons, shear zones, cracks or fissures.

D.2.3.1.7. Analysis should be performed of fault displacements, including the interpretation of the morphology of topographic fault scarps associated with or produced by surface rupture. Fault scarp morphology is useful for estimating the age of last displacement (in conjunction with the appropriate geochronological methods described NUREG/CR-5562 (Ref. D.6), approximate magnitude of the associated earthquake, recurrence intervals, slip rate, and the nature of the causative fault at depth.

D.2.3.2 Subsurface Investigations at the Site [within 1 km (0.5 mi)]

Subsurface investigations at the site to identify and describe potential seismogenic sources or capable tectonic sources and to obtain required geotechnical information are described in Regulatory Guide 1.132 (Ref. D.5) and updated in NUREG/CR-5738 (Ref. D.7). The investigations include, but may not be confined to, the following:

D.2.3.2.1. Geophysical investigations that have been useful in the past include magnetic and gravity surveys, seismic reflection and seismic refraction surveys, bore-hole geophysics, electrical surveys, and ground-penetrating radar surveys.

D.2.3.2.2. Core borings to map subsurface geology and obtain samples for testing such as determining the properties of the subsurface soils and rocks and geochronological analysis;

D.2.3.2.3. Excavation and logging of trenches across geological features to obtain samples for the geochronological analysis of those features.

D.2.3.2.4. At some sites, deep unconsolidated material/soil, bodies of water, or other material may obscure geologic evidence of past activity along a tectonic structure. In such cases, the analysis of evidence elsewhere along the structure can be used to evaluate its characteristics in the vicinity of the site.

In the CEUS it may not be possible to reasonably demonstrate the age of youngest activity on a tectonic structure with adequate deterministic certainty. In such cases the uncertainty should be quantified; the NRC staff will accept evaluations using the methods described in NUREG/CR-5503 (Ref. D.3). A demonstrated tectonic association of such structures with geologic structural features or tectonic processes that are geologically old (at least pre-Quaternary) should be acceptable as an age indicator in the absence of conflicting evidence.

D.2.3.3 Surface-Fault Rupture and Associated Deformation at the Site

A site that has a potential for fault rupture at or near the ground surface and associated deformation should be avoided. Where it is determined that surface deformation need not be taken into account, sufficient data or detailed studies to reasonably support the determination should be presented. Requirements for setback distance from active faults for hazardous waste treatment, storage and disposal facilities can be found in U.S. Environmental Protection Agency regulations (40 CFR Part 264).

The presence or absence of Quaternary faulting at the site needs to be evaluated to determine whether there is a potential hazard that is due to surface faulting. The potential for surface fault rupture should be characterized by evaluating (1) the location and geometry of faults relative to the site, (2) nature and amount of displacement (sense of slip, cumulative slip, slip per event, and nature and extent of related folding and/or secondary faulting), and (3) the likelihood of displacement during some future period of concern (recurrence interval, slip rate, and elapsed time since the most recent displacement). Acceptable methods and approaches for conducting these evaluations are described in NUREG/CR-5503 (Ref. D.3); acceptable geochronology dating methods are described in NUREG/CR-5562 (Ref. D.7).

For assessing the potential for fault displacement, the details of the spatial pattern of the fault zone (e.g., the complexity of fault traces, branches, and en echelon patterns) may be important as they may define the particular locations where fault displacement may be expected in the future. The amount of slip that might be expected to occur can be evaluated directly based on paleoseismic investigations or it can be estimated indirectly based on the magnitude of the earthquake that the fault can generate.

Both non-tectonic and tectonic deformation can pose a substantial hazard to an ISFSI or MRS, but there are likely to be differences in the approaches used to resolve the issues raised by the two types of phenomena. Therefore, non-tectonic deformation should be distinguished from tectonic deformation at a site. In past nuclear power plant licensing activities, surface displacements caused by phenomena other than tectonic phenomena have been confused with tectonically induced faulting. Such structures, such as found in karst terrain; and growth faulting, occurring in the Gulf Coastal Plain or in other deep soil regions, cause extensive subsurface fluid withdrawal.

Glacially induced faults generally do not represent a deep-seated seismic or fault displacement hazard because the conditions that created them are no longer present. However, residual stresses from Pleistocene glaciation may still be present in glaciated regions, although they are of less concern than active tectonically induced stresses. These features should be investigated with respect to their relationship to current in situ stresses.

The nature of faults related to collapse features can usually be defined through geotechnical investigations and can either be avoided or, if feasible, adequate engineering fixes can be provided.

Large, naturally occurring growth faults as found in the coastal plain of Texas and Louisiana can pose a surface displacement hazard, even though offset most likely occurs at a much less rapid rate than that of tectonic faults. They are not regarded as having the capacity to generate damaging vibratory ground motion, can often be identified and avoided in siting, and their displacements can be monitored. Some growth faults and antithetic faults related to growth faults and fault zones should be applied in regions where growth faults are known to be present. Local human-induced growth faulting can be monitored and controlled or avoided.

If questionable features cannot be demonstrated to be of non-tectonic origin, they should be treated as tectonic deformation.

D.2.4 Site Geotechnical Investigations and Evaluations

D.2.4.1 Geotechnical Investigations

The geotechnical investigations should include, but not necessarily be limited to, (1) defining site soil and near-surface geologic strata properties as may be required for hazard evaluations, engineering analyses, and seismic design, (2) evaluating the effects of local soil and site geologic strata on ground motion at the ground surface, (3) evaluating dynamic properties of the near-surface soils and geologic strata, (4) conducting soil-structure interaction analyses, and (5) assessing the potential for soil failure or deformation induced by ground shaking (liquefaction, differential compaction, land sliding).

The extent of investigation to determine the geotechnical characteristics of a site depends on the site geology and subsurface conditions. By working with experienced geotechnical engineers and geologists, an appropriate scope of investigations can be developed for a particular facility following the guidance contained in Regulatory Guide 1.132 (Ref. D.5) updated with NUREG/CR-5738 (Ref. D.6). The extent of subsurface investigations is dictated by the foundation requirements and by the complexity of the anticipated subsurface conditions. The locations and spacing of borings, soundings, and exploratory excavations should be chosen to adequately define subsurface conditions. Subsurface explorations should be chosen to adequately define subsurface conditions; exploration sampling points should be located to permit the construction of geological cross sections and soil profiles through foundations of safety-related structures and other important locations at the site.

Sufficient geophysical and geotechnical data should be obtained to allow for reasonable assessments of representative soil profile and soil parameters and to reasonably quantify variability. The guidance found in Regulatory Guide 1.132 (Ref. D.5) and NUREG/CR-5738 (Ref. D.6) is acceptable. In general, this guidance should be adapted to the requirements of the site to establish the scope of geotechnical investigations for the site as well as the appropriate methods that will be used.

For ISFSIs co-located with existing nuclear plants, site investigations should be conducted if the existing site information is not available or insufficient. Soil/rock profiles (cross-sections) at the locations of the facilities should be provided based on the results of site investigations. The properties required are intimately linked to the designs and evaluations to be conducted. For example, for analyses of soil response effects, assessment of strain dependent-soil-dynamic modulus and damping characteristics are required. An appropriate site investigation program should be developed in consultation with the geotechnical engineering representative of the project team.

Subsurface conditions should be investigated by means of borings, soundings, well logs, exploratory excavations, sampling, geophysical methods (e.g., cross-hole, down-hole, and geophysical logging) that adequately assess soil and ground water conditions and other methods described in NUREG/CR-5738 (Ref. D.6). Appropriate investigations should be made to determine the contribution of the subsurface soils and rocks to the loads imposed on the structures.

A laboratory testing program should be carried out to identify and classify the subsurface soils and rocks and to determine their physical and engineering properties. Laboratory tests for both static and dynamic properties (e.g., shear modulus, damping, liquefaction resistance, etc.) are generally required. The dynamic property tests should include, as appropriate, cyclic triaxial tests, cyclic simple shear tests, cyclic torsional shear tests, and resonant column tests. Both static and dynamic tests should be conducted as recommended in American Society for Testing and Materials (ASTM) standards or test procedures acceptable to the staff. The ASTM specification numbers for static and dynamic laboratory tests can be found in the annual books of ASTM Standards, Volume 04.08. Examples of soil dynamic property and strength tests are shown in Table D.1. Sufficient laboratory test data should be obtained to allow for reasonable assessments of mean values of soil properties and their potential variability.

For coarse geological materials such as coarse gravels and sand-gravel mixtures, special testing equipment and testing facility should be used. Larger sample size is required for laboratory tests on this type of materials (e.g., samples with 12-inch diameter were used in the Rockfalls Testing Facility). It is generally difficult to obtain in situ undisturbed samples of unconsolidated gravelly soils for laboratory tests. If it is not feasible to collect test samples and, thus, no laboratory test results are available, the dynamic properties should be estimated from the published data of similar gravelly soils.

Table D.1 Examples of Soil Dynamic Property and Strength Tests

D 3999-91 (Ref. D.8)	Standard Test Method for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus
D 4015-92 (Ref. D.9)	Standard Test Methods for Modulus and Damping of Soils by the Resonant-Column Method
D 5311-92 (Ref. D10)	Standard Test Method for Load-Controlled Cyclic Triaxial Strength of Soil

D.2.4.2 Seismic Wave Transmission Characteristics of the Site

To be acceptable, the seismic wave transmission characteristics (spectral amplification or deamplification) of the materials overlying bedrock at the site are described as a function of the significant structural frequencies. The following material properties should be determined for each stratum under the site: (1) thickness, seismic compressional and shear wave velocities, (2) bulk densities, (3) soil index properties and classification, (4) shear modulus and damping variations with strain level, and (5) the water table elevation and its variation throughout the site.

Where vertically propagating shear waves may produce the maximum ground motion, a one-dimensional equivalent-linear analysis or nonlinear analysis may be appropriate. Where horizontally propagating shear waves, compressional waves, or surface waves may produce the maximum ground motion, other methods of analysis may be more appropriate. However, since some of the variables are not well defined and investigative techniques are still in the developmental stage, no specific generally agreed-upon procedures can be recommended at this time. Hence, the staff must use discretion in reviewing any method of analysis. To ensure appropriateness, site response characteristics determined from analytical procedures should be compared with historical and instrumental earthquake data, when such data are available.

D.2.4.3 Site Response Analysis for Soil Sites

As part of quantification of earthquake ground motions at an ISFSI or MRS site, an analysis of soil response effects on ground motions should be performed. A specific analysis is not required at a hard rock site. Site response analyses (often referred to as site amplification analyses) are relatively more important when the site surficial soil layer is a soft clay and/or when there is a high stiffness contrast (wave velocity contrast) between a shallow soil layer and underlying bedrock. Such conditions have shown strong local soil effects on ground motion. Site response analyses are always important for sites that have predominant frequencies within the range of interest for the DE ground motions. Thus, the stiffness of the soil and bedrock as well as the depth of soil deposit should be carefully evaluated.

In performing a site response analysis, the ground motions (usually acceleration time histories) defined at bedrock or outcrop are propagated through an analytical model of the site soils to determine the influence of the soils on the ground motions. The required soil parameters for the site response analysis include the depth, soil type, density, shear modulus and damping, and their variations with strain levels for each of the soil layers. Internal friction angle, cohesive strength, and over-consolidation ratio for clay are also needed for non-linear analyses. The strain dependent shear modulus and damping curves should be developed based on site-specific testing results and supplemented as appropriate by published data for similar soils. The effects of confining pressures (that reflect the depths of the soil) on these strain-dependent soil dynamic characteristics should be assessed and considered in site response analysis. The variability in these properties should be accounted in the site response analysis. The results of the site response analysis should show the input motion (rock response spectra), output motion (surface response spectra), and spectra amplification function (site ground motion transfer function).

D.2.4.4 Ground Motion Evaluations

D.2.4.4.1. Liquefaction is a soil behavior phenomenon in which cohesionless soils (sand, silt, or gravel) under saturated conditions lose a substantial part or all of their strength because of high pore water pressures generated in the soils by strong ground motions induced by earthquakes. Potential effects of liquefaction include reduction in foundation bearing capacity, settlements, land sliding and lateral movements, flotation of lightweight structures (such as tanks) embedded in the liquefied soil, and increased lateral pressures on walls retaining liquefied soil. Guidance in Draft Regulatory Guide DG-1105, "Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites" (Ref. D.11), is being developed to be used for evaluating the site for liquefaction potential.

Investigations of liquefaction potential typically involve both geological and geotechnical engineering assessments. The parameters controlling liquefaction phenomena are (1) the lithology of the soil at the site, (2) the ground water conditions, (3) the behavior of the soil under dynamic loadings, and (4) the potential severity of the vibratory ground motion. The following site-specific data should be acquired and used along with state-of-the-art evaluation procedures (e.g., Ref. D.12, Ref. D.13).

- Soil grain size distribution, density, static and dynamic strength, stress history, and geologic age of the sediments;
- Ground water conditions;
- Penetration resistance of the soil, e.g., Standard Penetration Test (SPT), Cone Penetration Test (CPT);
- Shear wave velocity of the soil velocity of the soil;
- Evidence of past liquefaction; and
- Ground motion characteristics.

A soil behavior phenomenon similar to liquefaction is strength reduction in sensitive clays. Although this behavior phenomenon is relatively rare in comparison to liquefaction, it should not be overlooked as a potential cause for land sliding and lateral movements. Therefore, the existence of sensitive clays at the site should be identified.

D.2.4.4.2. Ground settlement during and after an earthquake that is due to dynamic loads, change of ground water conditions, soil expansion, soil collapse, erosion, and other causes must be considered. Ground settlement that is due to the ground shaking induced by an earthquake can be caused by two factors: (1) compaction of dry sands by ground shaking and (2) settlement caused by dissipation of dynamically induced pore water in saturated sands. Differential settlement would cause more damage to facilities than would uniform settlement. Differential compaction of cohesionless soils and resulting differential ground settlement can accompany liquefaction or may occur in the absence of liquefaction. The same types of geologic information and soil data used in liquefaction potential assessments, such as the SPT value, can also be used in assessing the potential for differential compaction. Ground subsidence has been observed at the surface above relatively shallow cavities formed by mining activities (particularly coal mines) and where large quantities of salt, oil, gas, or ground water have been extracted (Ref. D.14). Where these conditions exist near a site, consideration and investigation must be given to the possibility that surface subsidence will occur.

D.2.4.4.3. The stability of natural and man-made slopes must be evaluated when their failures would affect the safety and operation of an ISFSI or MRS. In addition to land sliding facilitated by liquefaction-induced strength reduction, instability and deformation of hillside and embankment slopes can occur from the ground shaking inertia forces causing a temporary exceedance of the strength of soil or rock. The slip surfaces of previous landslides, weak planes or seams of subsurface materials, mapping and dating paleo-slope failure events, loss of shear strength of the materials caused by the natural phenomena hazards such as liquefaction or reduction of strength due to wetting, hydrological conditions including pore pressure and seepage, and loading conditions imposed by the natural phenomena events must all be considered in determining the potential for instability and deformations. Various possible modes of failure should be considered. Both static and dynamic analyses must be performed for the stability of the slopes.

The following information, at a minimum, is to be collected for the evaluation of slope instability:

- Slope cross sections covering areas that would be affected the slope stability;
- Soil and rock profiles within the slope cross sections;
- Static and dynamic soil and rock properties, including densities, strengths, and deformability;
- Hydrological conditions and their variations; and
- Rock fall events.

D.2.5 Geochronology

An important part of the geologic investigations to identify and define potential seismic sources is the geochronology of geologic materials. An acceptable classification of dating methods is based on the rationale described in Reference D.15. The following techniques, which are presented according to that classification, are useful in dating Quaternary deposits.

D.2.5.1 Sidereal Dating Methods

- Dendrochronology
- Varve chronology
- Schlerochronology

D.2.5.2 Isotopic Dating Methods

- Radiocarbon
- Cosmogenic nuclides - ^{36}Cl, ^{10}Be, ^{21}Pb, and ^{26}Al
- Potassium argon and argon-39-argon-40
- Uranium series - ^{234}U-^{230}Th and ^{235}U- ^{231}Pa
- ^{210}Lead
- Uranium-lead, thorium-lead

D.2.5.3 Radiogenic Dating Methods

- Fission track
- Luminescence

- Electron spin resonance

D.2.5.4 Chemical and Biological Dating Methods

- Amino acid racemization
- Obsidian and tephra hydration
- Lichenometry

D.2.5.6 Geomorphic Dating Methods

- Soil profile development
- Rock and mineral weathering
- Scarp morphology

D.2.5.7 Correlation Dating Methods

- Paleomagnetism (secular variation and reversal stratigraphy)
- Tephrochronology
- Paleontology (marine and terrestrial)
- Global climatic correlations - Quaternary deposits and landforms, marine stable isotope records, etc.

In the CEUS, it may not be possible to reasonably demonstrate the age of last activity of a tectonic structure. In such cases the NRC staff will accept association of such structures with geologic structural features or tectonic processes that are geologically old (at least pre-Quaternary) as an age indicator in the absence of conflicting evidence.

These investigative procedures should also be applied, where possible, to characterize offshore structures (faults or fault zones, and folds, uplift, or subsidence related to faulting at depth) for coastal sites or those sites located adjacent to landlocked bodies of water. Investigations of offshore structures will rely heavily on seismicity, geophysics, and bathymetry rather than conventional geologic mapping methods that normally can be used effectively onshore. However, it is often useful to investigate similar features onshore to learn more about the significant offshore features.

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APPENDIX E
PROCEDURE FOR THE EVALUATION OF NEW GEOSCIENCES INFORMATION OBTAINED FROM THE SITE-SPECIFIC INVESTIGATIONS

E.1 INTRODUCTION

This appendix provides methods acceptable to the NRC staff for assessing the impact of new information obtained during site-specific investigations on the data base used for the probabilistic seismic hazard analyses (PSHA).

Regulatory Position 4 in this guide describes acceptable PSHAs that were developed by the Lawrence Livermore National Laboratory (LLNL) and the Electric Power Research Institute (EPRI) to characterize the seismic hazard for nuclear power plants and to develop the Safe Shutdown Earthquake (SSE). The procedure to determine the design earthquake ground motion (DE) outlined in this guide relies primarily on either the LLNL or EPRI PSHA results for the Central and Eastern United States (CEUS).

It is necessary to evaluate the geological, seismological, and geophysical data obtained from the site-specific investigations to demonstrate that these data are consistent with the PSHA data bases of these two methodologies. If new information identified by the site-specific investigations would result in a significant increase in the hazard estimate for a site, and this new information is validated by a strong technical basis, the PSHA may have to be modified to incorporate the new technical information. Using sensitivity studies, it may also be possible to justify a lower hazard estimate with an exceptionally strong technical basis. However, it is expected that large uncertainties in estimating seismic hazard in the CEUS will continue to exist in the future, and substantial delays in the licensing process will result from trying to justify a lower value with respect to a specific site.

In general, major recomputations of the LLNL and EPRI data base are planned periodically (approximately every 10 years), or when there is an important new finding or occurrence. The overall revision of the data base will also require a reexamination of the reference probability discussed in Appendix B.

E.2 POSSIBLE SOURCES OF NEW INFORMATION THAT COULD AFFECT THE SSE

Types of new data that could affect the PSHA results can be put in three general categories: seismic sources, earthquake recurrence models or rates of deformation, and ground motion models.

E.2.1 Seismic Sources

There are several possible sources of new information from the site-specific investigations that could affect the seismic hazard. Continued recording of small earthquakes, including microearthquakes, may indicate the presence of a localized seismic source. Paleoseismic evidence, such as paleoliquefaction features or displaced Quaternary strata, may indicate the presence of a previously unknown tectonic structure or a larger amount of activity on a known structure than was previously considered. Geophysical studies (aeromagnetic, gravity, and seismic reflection/refraction) may identify crustal structures that suggest the presence of previously unknown seismic sources. In situ stress measurements and the mapping of tectonic structures in the future may indicate potential seismic sources.

Detailed local site investigations often reveal faults or other tectonic structures that were unknown, or reveal additional characteristics of known tectonic structures. Generally, based on past licensing experience in the CEUS, the discovery of such features will not require a modification of the seismic sources provided in the LLNL and EPRI studies. However, initial evidence regarding a newly discovered tectonic structure in the CEUS is often equivocal with respect to activity, and additional detailed investigations are required. By means of these detailed investigations, and based on past licensing activities, previously unidentified tectonic structures can usually be shown to be inactive or otherwise insignificant to the seismic design basis of the facility, and a modification of the seismic sources provided by the LLNL and EPRI studies will not be required. On the other hand, if the newly discovered features are relatively young, possibly associated with earthquakes that were large and could impact the hazard for the proposed facility, a modification may be required.

Of particular concern is the possible existence of previously unknown, potentially active tectonic structures that could have moderately sized, but potentially damaging, near-field earthquakes or could cause surface displacement. Also of concern is the presence of structures that could generate larger earthquakes within the region than previously estimated.

Investigations to determine whether there is a possibility for permanent ground displacement are especially important in view of the provision to allow for a combined licensing procedure under 10 CFR Part 52 as an alternative to the two-step procedure of the past (Construction Permit and Operating License). In the past at numerous nuclear power plant sites, potentially significant faults were identified when excavations were made during the construction phase prior to the issuance of an operating license, and extensive additional investigations of those faults had to be carried out to properly characterize them.

E.2.2 Earthquake Recurrence Models

There are three elements of the source zone's recurrence models that could be affected by new site-specific data: (1) the rate of occurrence of earthquakes, (2) their maximum magnitude, and (3) the form of the recurrence model (e.g.,a change from truncated exponential to a characteristic earthquake model). Among the new site-specific information that is most likely to have a significant impact on the hazard is the discovery of paleoseismic evidence such as extensive soil liquefaction features, which would indicate with reasonable confidence that much larger estimates of the maximum earthquake than those predicted by the previous studies would ensue. The paleoseismic data could also be significant even if the maximum magnitudes of the previous studies are consistent with the paleo-earthquakes if there are sufficient data to develop return period estimates significantly shorter than those previously used in the probabilistic analysis. The paleoseismic data could also indicate that a characteristic earthquake model would be more applicable than a truncated exponential model.

In the future, expanded earthquake catalogs will become available that will differ from the catalogs used by the previous studies. Generally, these new catalogues have been shown to have only minor impacts on estimates of the parameters of the recurrence models. Cases that might be significant include the discovery of records that indicate earthquakes in a region that had no seismic activity in the previous catalogs, the occurrence of an earthquake larger than the largest historic earthquakes, re-evaluating the largest historic earthquake to a significantly larger magnitude, or the occurrence of one or more moderate to large earthquakes (magnitude 5.0 or greater) in the CEUS.

Geodetic measurements, particularly satellite-based networks, may provide data and interpretations of rates and styles of deformation in the CEUS that can have implications for earthquake recurrence. New hypotheses regarding present-day tectonics based on new data or reinterpretation of old data may be developed that were not considered or given high weight in the EPRI or LLNL PSHA. Any of these cases could have an impact on the estimated maximum earthquake if the result is larger than the values provided by LLNL and EPRI.

E.2.3 Ground Motion Attenuation Models

Alternative ground motion attenuation models may be used to determine the site-specific spectral shape as discussed in Regulatory Position 4 and Appendix F of this regulatory guide. If the ground motion models used are a major departure from the original models used in the hazard analysis and are likely to have impacts on the hazard results of many sites, a re-evaluation of the reference probability may be needed. Otherwise, a periodic (e.g., every 10 years) reexamination of the PSHA and the associated data base is considered appropriate to incorporate new understanding regarding ground motion attenuation models.

E.3 PROCEDURE AND EVALUATION

The EPRI and LLNL studies provide a wide range of interpretations of the possible seismic sources for most regions of the CEUS, as well as a wide range of interpretations for all the key parameters of the seismic hazard model. The first step in comparing the new information with those interpretations is determining whether the new information is consistent with the following LLNL and EPRI parameters: (1) the range of seismogenic sources as interpreted by the seismicity experts or teams involved in the study, (2) the range of seismicity rates for the region around the site as interpreted by the seismicity experts or teams involved in the studies, and (3) the range of maximum magnitudes determined by the seismicity experts or teams. The new information is considered not significant and no further evaluation is needed if it is consistent with the assumptions used in the PSHA, no additional alternative seismic sources or seismic parameters are needed, or it supports maintaining or decreasing the site mean seismic hazard.

An example is a new ISFSI co-located near an existing nuclear power plant site that was recently investigated by state-of-the-art geosciences techniques and evaluated by current hazard methodologies. Detailed geological, seismological, and geophysical site-specific investigations would be required to update existing information regarding the new site, but it is very unlikely that significant new information would be found that would invalidate the previous PSHA.

On the other hand, after evaluating the results of the site-specific investigations, if there is still uncertainty about whether the new information will affect the estimated hazard, it will be necessary to evaluate the potential impact of the new data and interpretations on the mean of the range of the input parameters. Such new information may indicate the addition of a new seismic source, a change in the rate of activity, a change in the spatial patterns of seismicity, an increase in the rate of deformation, or the observation of a relationship between tectonic structures and current seismicity. The new findings should be assessed by comparing them with the specific input of each expert or team that participated in the PSHA. Regarding a new source, for example, the specific seismic source characterizations for each expert or team (such as tectonic feature being modeled, source geometry, probability of being active, maximum earthquake magnitude, or occurrence rates) should be assessed in the context of the significant new data and interpretations.

It is expected that the new information will be within the range of interpretations in the existing data base, and the data will not result in an increase in overall seismicity rate or increase in the range of maximum earthquakes to be used in the probabilistic analysis. It can then be concluded that the current LLNL or EPRI results apply. It is possible that the new data may necessitate a change in some parameter. In this case, appropriate sensitivity analyses should be performed to determine whether the new site-specific data could affect the ground motion estimates at the reference probability level.

An example is a consideration of the seismic hazard near the Wabash River Valley (Ref. E.1). Geological evidence found recently within the Wabash River Valley and several of its tributaries indicated that an earthquake much larger than any historic event had occurred several thousand years ago in the vicinity of Vincennes, Indiana. A review of the inputs by the experts and teams involved in the LLNL and EPRI PSHAs revealed that many of them had made allowance for this possibility in their tectonic models by assuming the extension of the New Madrid Seismic Zone northward into the Wabash Valley. Several experts had given strong weight to the relatively high seismicity of the area, including the number of magnitude five historic earthquakes that have occurred, and thus had assumed the larger event. This analysis of the source characterizations of the experts and teams resulted in the conclusion by the analysts that a new PSHA would not be necessary for this region because an event similar to the prehistoric earthquake had been considered in the existing PSHAs.

A third step would be required if the site-specific geosciences investigations revealed significant new information that would substantially affect the estimated hazard. Modification of the seismic sources would more than likely be required if the results of the detailed local and regional site investigations indicate that a previously unknown seismic source is identified in the vicinity of the site. A hypothetical example would be the recognition of geological evidence of recent activity on a fault near a site in the SCR similar to the evidence found on the Meers Fault in Oklahoma (Ref. E.2). If such a source is identified, the same approach used in the active tectonic regions of the WUS should be used to assess the largest earthquake expected and the rate of activity. If the resulting maximum earthquake and the rate of activity are higher than those provided by the LLNL or EPRI experts or teams regarding seismic sources within the region in which this newly discovered tectonic source is located, it may be necessary to modify the existing interpretations by introducing the new seismic source and developing modified seismic hazard estimates for the site. The same would be true if the current ground motion models are a major departure from the original models. These occurrences would likely require performing a new PSHA using the updated data base, and may require determining the appropriate reference probability.

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APPENDIX F
PROCEDURE TO DETERMINE THE DESIGN EARTHQUAKE GROUND MOTION

F.1 INTRODUCTION

This appendix elaborates on Step 4 of Regulatory Position 4 of this guide, which describes an acceptable procedure to determine the design earthquake ground motion (DE). The DE is defined in terms of the horizontal and vertical free-field ground motion response spectra at the free ground surface. It is developed with consideration of local site effects and site seismic wave transmission effects. The DE response spectrum can be determined by scaling a site-specific spectral shape determined for the controlling earthquakes or by scaling a standard broad-band spectral shape to envelope the ground motion levels for 1 Hz ($S_{a,1}$) and 10 Hz ($S_{a,10}$), as determined in Step C.2-2 of Appendix C to this guide. The standard response spectrum is generally specified at 5 percent critical damping.

It is anticipated that a regulatory guide will be developed that provides guidance on assessing site-specific effects and determining smooth design response spectra, taking into account recent developments in ground motion modeling and site amplification studies (for example, Ref. F.1).

F.2 DISCUSSION

For engineering purposes, it is essential that the design ground motion response spectrum be a broad-band smooth response spectrum with adequate energy in the frequencies of interest. In the past, it was general practice to select a standard broad-band spectrum, such as the spectrum in Regulatory Guide 1.60 (Ref. F.2), and scale it by a peak ground motion parameter [usually peak ground acceleration (PGA)], which is derived based on the size of the controlling earthquake. Past practices to define the DE are still valid and, based on this consideration, the following three possible situations are depicted in Figures F.1 to F.3.

Figure F.1 depicts a situation in which a site is to be used for a certified ISFSI or MRS design (if available) with an established DE. In this example, the certified design DE spectrum compares favorably with the site-specific response spectra determined in Step 2 or 3 of Regulatory Position 4.

Figure F.2 depicts a situation in which a standard broad-band shape is selected and its amplitude is scaled so that the design DE envelopes the site-specific spectra.

Figure F.3 depicts a situation in which a specific smooth shape for the design DE spectrum is developed to envelope the site-specific spectra. In this case, it is particularly important to be sure that the DE contains adequate energy in the frequency range of engineering interest and is sufficiently broad-band.

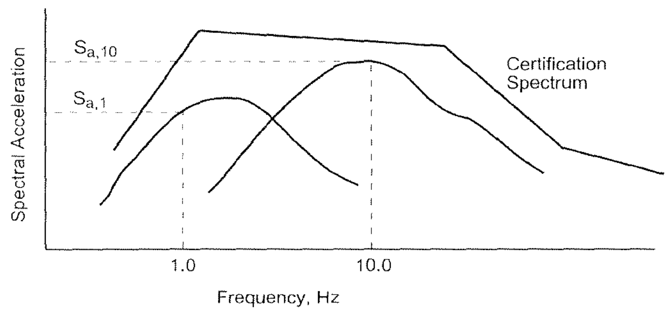

Figure F.1 Use of DE Spectrum of a Certified Design

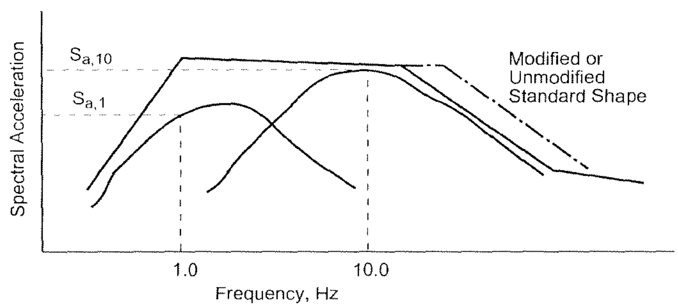

Figure F.2 Use of a Standard Shape for DE

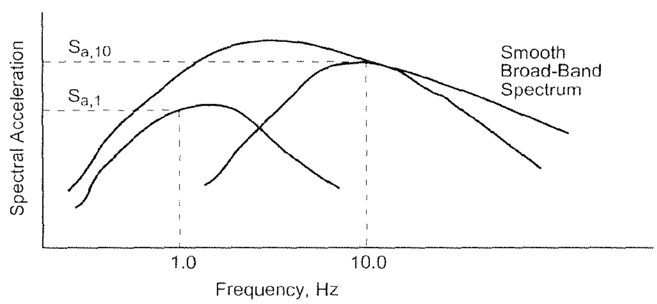

Figure F.3 Development of a Site-Specific DE Spectrum

(**Note:** The above figures illustrate situations for a rock site. For other site conditions, the DE spectra are compared at free-field after performing site amplification studies as discussed in Step 3 of Regulatory Position 4.)

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REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this draft regulatory guide. The regulatory analysis "Regulatory Analysis of Geological and Seismological Characteristics for and Design of Dry Cask Independent Spent Fuel Storage Installations (10 CFR Part 72)," was prepared for the amendments, and it provides the regulatory basis for this guide and examines the costs and benefits of the rule as implemented by the guide. A copy of the regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, as Attachment 3 to SECY-02-0043. The PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or 1-(800)397-4209; fax (301)415-3548; e-mail <PDR@NRC.GOV>.

Environmental Assessment of Geological and Seismological Characteristics for Siting and Design of Dry Cask Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations

Draft Report

U.S. Nuclear Regulatory Commission
Office of Nuclear Materials Safety and Safeguards

July 2002

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Executive Summary

This document presents the Environmental Assessment of the U.S. Nuclear Regulatory Commission's (NRC or the Commission) proposal to amend its licensing requirements in 10 CFR Part 72 pertaining to the seismic siting and design criteria for dry cask modes of storage of (1) spent nuclear fuel in an independent spent fuel storage installation (ISFSI) and (2) spent nuclear fuel and solid high-level radioactive waste in a monitored retrievable storage installation (MRS). For purposes of this document, the term "ISFSI" is used to include both dry ISFSI and MRS facilities, as appropriate. The Commission does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because applications for this means of storage are not expected and it is not cost-effective to allocate resources to develop the technical bases for such an expansion of the rulemaking. The Commission also does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to dry modes of storage that do not use casks because of the lack of experience in licensing these facilities. The Commission considered a number of options to change the siting and design requirements in Part 72.

The rulemaking proposes the following changes:

1. Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a probabilistic seismic hazard analysis (PSHA) or other suitable sensitivity analyses, for determining the design earthquake ground motion (DE). All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

2. Allow new ISFSI applicants to use a DE appropriate for and commensurate with the risk associated with an ISFSI (§ 72.103). A draft regulatory guide accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the safe shutdown earthquake (SSE) of a NPP, for ISFSI applications.

3. Require general licensees to evaluate that the designs of cask storage pads and areas adequately account for dynamic loads, in addition to static loads (§ 72.212).

The Commission intends to leave present § 72.102 in place to preserve the licensing basis of present ISFSIs. The proposed provisions would be added as a new § 72.103, which would provide the requirements that would be utilized for new specific license applicants.

The proposed changes are consistent with the Commission's strategic goals in that

- The rulemaking effort would increase NRC's effectiveness and efficiency by reducing the number of exemption requests that would need to be submitted and reviewed.

- This rule would maintain safety by selecting the DE to be commensurate with the risk associated with an ISFSI.

- The changes to the DE are considered risk-informed, consistent with NRC policy to develop risk-informed regulations.

- This rule would increase realism by enabling ISFSI applicants to use the state-of-the-art approach (PSHA or suitable sensitivity analyses) to more accurately characterize the seismicity of a site.

The Commission considered four options for this rulemaking:

<u>Option 1</u>.

No Action. The siting requirements for new dry cask ISFSIs would continue to conform to the existing requirements of §§ 72.102.

Option 1, the no-action alternative, would not result in any change to current seismic design criteria, nor would it affect the DE for ISFSI SSCs.

<u>Option 2</u>.

Require new Part 72 specific license applicants to conform to § 100.23 in lieu of Appendix A to Part 100.

No adverse environmental impacts are expected under Option 2. Under this option, certain applicants would be required to address uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or suitable sensitivity analyses, for developing the DE for ISFSIs. The use of PSHA or suitable sensitivity analyses for derivation of the DE would be more risk-informed than the deterministic approach. Under this option, all ISFSIs would still meet the radiological protection standards in §§ 72.104(a) and 72.106(b), and thus the degree of protection of the public health would not be compromised.

<u>Option 3</u>.

Require new Part 72 specific license applicants to conform to § 100.23 in lieu of Appendix A to Part 100, and also give them the option to use a graded approach to seismic design of the ISFSI SSCs.

No adverse environmental impacts are expected under Option 3. As under Option 2, derivation of DEs for ISFSIs using a risk-informed PSHA or suitable sensitivity analyses would be required for certain specific license applicants, and would be protective. Under the graded approach to developing design criteria for ISFSIs, the DE for SSCs important to safety designed for Category 2 events would still be the SSE for a NPP. For these SSCs, there is therefore no change in risk of radiological exposure. SSCs could be designed to withstand less stringent criteria (Category 1 events) only if the applicant's analysis provides reasonable assurance that the failure of the SSC would not cause the facility to exceed the radiological protection requirements of § 72.104(a) under normal operations. If the specific license applicant's analysis cannot support this conclusion, the SSC would have to be designed such that the facility can withstand more stringent criteria without impairing the ISFSI's capability to perform safety functions and not exceed the radiological protection requirements of §§ 72.104(a) and 72.106(b). Thus, no additional risk to the public would be incurred.

Option 4.

(1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

(2) Maintain the present Part 72 requirement of using a single-level DE, but allow for the use of a lower DE that is commensurate with the level of risk associated with an ISFSI. The draft regulatory guide, DG-3021 "Site Evaluations and Determination of Design Earthquake Ground Motion for Seismic Design of Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations," accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04 for ISFSI applications. This recommended level is lower than the present level of approximately 1.0E-04 (equivalent to the SSE for a NPP). Option 4 is similar to Options 2 and 3 in that it requires certain specific license applicants to address uncertainties in seismic hazard analysis to use a risk-informed PSHA or suitable sensitivity analyses for deriving the DE for ISFSIs. Thus, there would be no adverse effect associated with that aspect of this option. Option 4 is different from and 3 in that specific licensees would not be required to design any SSCs to withstand a DE as high as the SSE of a NPP. With more than 10 years of experience licensing dry cask storage systems, together with analyses demonstrating their robust behavior in accident scenarios involving earthquakes, the NRC staff concludes that designing ISFSI SSCs using a single-level DE with a ground motion that is commensurate with the level of risk associated with an ISFSI, is sufficient to provide reasonable assurance in demonstrating public health and safety.

Options Summary.

Overall, no adverse environmental impacts will result from any of the options identified. Dry storage casks used at an ISFSI are passive systems with natural cooling sufficient to maintain safe temperatures and a robustness or structural integrity to withstand external forces. The cask walls provide adequate shielding and no radioactive products are released under any credible accident conditions. Other systems, structures, and components (SSCs) will also be designed to standards affording a high degree of environmental protection under normal operations and credible accident conditions. In addition, none of the proposed changes will significantly affect the construction or operation of an ISFSI facility.

Additional Change

The Commission is also proposing a change to § 72.212(b)(2)(i)(B) to require that general licensees evaluate dynamic loads (in addition to static loads) in the design of cask storage pads and areas. This proposed change is an additional modification, separate from the changes proposed in the options above.

NRC would change § 72.212(b)(2)(i)(B) to require written evaluations, prior to use, establishing that cask storage pads and areas have been evaluated for the static and dynamic loads of the stored casks. No adverse environmental impacts are expected to result from the proposed change to evaluate dynamic as well as static loads in the design of ISFSI storage pads and areas. The proposed changes are intended to require that general licensees perform appropriate analyses to ensure that the seismic design bases for the casks are met and that casks are not placed in an unanalyzed condition. Therefore, these proposed changes are necessary to assure adequate protection to occupational and public health and safety. The proposed changes to § 72.212 would not actually impose new burden on the general licensees because they currently need to consider dynamic loads to meet the requirements in § 72.212(b)(2)(i)(A). Since the general licensees currently evaluate dynamic loads for evaluating the cask pads and areas, the proposed changes to § 72.212(b)(2)(i)(B) would not actually require any present general licensees operating an ISFSI to re-perform any written evaluations previously undertaken.

1.0 Introduction

The Nuclear Regulatory Commission (NRC) is proposing to amend its siting and design requirements in 10 CFR Part 72 pertaining to the seismic siting and design criteria for dry cask modes of storage of (1) spent nuclear fuel in an ISFSI and (2) spent nuclear fuel in solid high-level radioactive waste in a U.S. Department of Energy (DOE) MRS. For this document, the term "ISFSI" is used to include both ISFSI and MRS facilities, as appropriate. The Commission does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because applications for this means of storage are not expected and it is not cost-effective to allocate resources to develop the technical bases for such an expansion of the rulemaking. The Commission also does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to dry modes of storage that do not use casks because of the lack of experience in licensing these facilities.

The Commission considered four seismic evaluation options. This draft Environmental Assessment (EA) is a part of the Commission's analysis of the options being considered and is a supporting document for the *Federal Register* Notice containing the proposed rule. The purpose of this draft EA is to evaluate the potential environmental impacts associated with the regulatory changes as required by the National Environmental Policy Act (NEPA). This document presents background material, describes the purpose and need for the proposed action, outlines the proposed action and alternatives being considered, and evaluates the environmental consequences of the proposed action and alternatives.

1.1 Background

In 1980, the Commission added 10 CFR Part 72 to its regulations to establish licensing requirements for the storage of spent fuel in an ISFSI (45 FR 74693, November 12, 1980). Subpart E of Part 72 contains siting evaluation factors that must be investigated and assessed with respect to the siting of an ISFSI, including a requirement for evaluation of geological and seismological characteristics. The original regulations envisioned these facilities as spent fuel pools or single, massive dry storage structures. The regulations required seismic evaluations equivalent to those for a NPP when the ISFSI is located in the western U.S. (west of approximately 104^0 west longitude), or in areas of known seismic activity in the central and eastern U.S. A seismic design requirement, equivalent to the requirements for a NPP (Appendix A to 10 CFR Part 100) seemed appropriate for these types of facilities, given the potential accident scenarios. For those sites located in the central and eastern U.S., and not in areas of known seismic activity, the regulations allowed for less stringent alternatives.

For other types of ISFSI designs, the regulation required a site-specific investigation to establish site suitability commensurate with the specific requirements of the proposed ISFSI. The Commission explained that for ISFSIs which do not involve massive structures, such as dry storage casks and canisters, the required DE will be determined on a case-by-case basis until more experience is gained with the licensing of these types of units (45 FR 74697).

For sites located in the western U.S., or in the eastern U.S. in areas of known seismic activity, the regulations in § 72.102 require the use of the procedures in Appendix A to Part 100 for determining the design basis vibratory ground motion at a site. Appendix A to Part 100 requires the use of "deterministic" approaches in the development of a single set of earthquake sources. The applicant develops for each source a postulated earthquake to be used to determine the ground motion that can affect the site, locates the postulated earthquake according to prescribed rules, and then calculates ground motions at the site.

Advances in the sciences of seismology and geology, along with the occurrence of some licensing issues not foreseen in the development of Appendix A to Part 100, have caused a number of difficulties in the application of this regulation to dry cask ISFSIs. Specific problematic areas include the following:

- Because the deterministic approach does not explicitly recognize uncertainties in geoscience parameters, PSHA methods and suitable sensitivity analyses were developed that allow explicit expressions for the uncertainty in ground motion estimates and provide a means for assessing sensitivity to various parameters. Yet Appendix A to Part 100 does not allow this application.

- The limitations in data and geologic and seismic analyses and the rapid accumulation of knowledge in the geosciences have required considerable latitude in judgment. The inclusion of detailed geoscience assessments in Appendix A has caused difficulties for applicants and the Commission by inhibiting the use of needed judgment and flexibility in applying basic principles to new situations.

- Various sections of Appendix A are subject to different interpretations. For ISFSI applications, some sections in the Appendix do not provide sufficient information for implementation. As a result, the Appendix has been the source of licensing delays and debate.

In 1996, the Commission amended 10 CFR Parts 50 and 100 to update the criteria used in decisions regarding NPP siting, including geologic and seismic engineering considerations for future NPPs (61 FR 65157, December 11, 1996). The amendments placed a new § 100.23 in the regulations requiring that the uncertainties in seismic hazard analysis associated with the determination of the SSE be addressed through an appropriate analysis, such as a PSHA or suitable sensitivity analyses in lieu of Appendix A. This approach takes into account the shortcomings in the earlier siting requirements and is based on developments in the field over the past two decades. Further, regulatory guides have been used to address implementation issues. For example, the Commission provided guidance for nuclear power plant license applicants in Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," and Standard Review Plan-NUREG 0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Reactors." However, the Commission left Appendix A to Part 100 in place to preserve the licensing basis for existing plants and confined the applicability of § 100.23 to new NPPs.

With over 10 years of experience licensing dry cask storage the Commission is now proposing a conforming change to 10 CFR Part 72 to require some sites to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. This approach parallels the change made to 10 CFR Part 100.

In comparison with a NPP, an operating ISFSI facility is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI facility does not have the variety and complexity of active systems necessary to support an operating NPP. Further, the robust cask design required for non-seismic considerations (e.g., drop event, shielding), assure low probabilities of failure from seismic events.

In the unlikely occurrence of a radiological release as a result of a seismic event, the radiological consequences to workers and the public are significantly lower than those that could arise at a NPP. This is because the conditions required for release and dispersal of significant quantities of radioactive material, such as high temperatures or pressures, are not present in an ISFSI. This is primarily due to the low heat-generation rate of spent fuel that has undergone more than one year of decay before storage in an ISFSI, and to the low inventory of volatile radioactive materials readily available for release to the environment. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. Short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel. Furthermore, even if the short-lived nuclides were present during a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the Commission believes that the seismically induced radiological risk associated with an ISFSI is less than the risk associated with a NPP and the use of a lower DE is appropriate.

2.0 Purpose and Need for Proposed Action

Part 72 currently requires siting and design of ISFSI facilities in accordance with requirements that were established for the licensing of nuclear power plants (Appendix A to Part 100). The purpose of the proposed changes to Part 72 is to (1) provide benefit from the experience gained in applying the existing regulation and from research, (2) incorporate state-of-the-art improvements in the geosciences and earthquake engineering, and (3) make the siting and design criteria risk-informed. These changes are needed because the current requirements are unnecessarily conservative for ISFSI applications, resulting in more costly facility designs, while not providing any measurable additional safety benefit.

The rulemaking proposes to:

1. Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

2. Allow new ISFSI applicants to use a DE appropriate for and commensurate with the risk associated with an ISFSI (§ 72.103). A draft regulatory guide accompanying this proposed rule recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications.

3. Require general licensees to evaluate that the designs of cask storage pads and areas adequately account for dynamic loads, in addition to static loads (§ 72.212).

NRC is considering three changes to its seismological and geological siting and design regulations for ISFSI applications.

(1) The first change considers the plausibility of requiring new applicants for sites located in either the western U.S. or in the eastern U.S. in areas of known seismic activity, and not co-located with a NPP, to address uncertainties in determining the DE ground motion seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation (§ 72.103).

The existing approach for determining a DE for an ISFSI, embodied in Appendix A to Part 100, relies on a "deterministic" approach. Using this deterministic approach, an applicant develops a single set of earthquake sources, develops for each source a postulated earthquake to be used as the source of ground motion that can affect the site, locates the postulated earthquake according to prescribed rules, and then calculates ground motions at the site.
Although this approach has worked reasonably well for the past several decades, in the sense that safe shutdown earthquake ground motions for NPPs sited with this approach are judged to be suitably conservative, the approach has not explicitly recognized uncertainties in geosciences

parameters. Because so little is known about earthquake phenomena (especially in the eastern U.S.), there have often been differences of opinion and differing interpretations among experts as to the largest earthquakes to be considered and ground-motion models to be used.

Probabilistic methods that have been developed in the past 15 to 20 years for evaluation of seismic safety of nuclear facilities allow explicit incorporation of different models for zonation, earthquake size, ground motion, and other parameters. The advantage of using these probabilistic methods is their ability to incorporate different models and data sets, thereby providing an explicit expression for the uncertainty in the ground motion estimates and a means of assessing sensitivity to various input parameters. The western and eastern U.S. have fundamentally different tectonic environments and histories of tectonic deformation. Consequently, application of these probabilistic methodologies has revealed the need to vary the fundamental PSHA methodology depending on the tectonic environment of the site.

In 1996, when the Commission accepted the use of a PSHA methodology or suitable sensitivity analyses in §100.23, it recognized that the uncertainties in seismological and geological information must be formally evaluated and appropriately accommodated in the determination of the SSE for seismic design of NPPs. The Commission further recognized that the nature of uncertainty and the appropriate approach to account for it depends on the tectonic environment of the site and on properly characterizing parameters input to the PSHA or suitable sensitivity analyses. Consequently, methods other than probabilistic methods such as sensitivity analyses may be adequate for some sites to account for uncertainties. The Commission believes that certain new applicants for ISFSI specific licenses, as described in section 3.0, must also account for these uncertainties instead of using the Appendix A to Part 100.

NRC staff will review the application using all available data including insights and information from previous licensing experience. Thus, the proposed approach requires thorough regional and site-specific geoscience investigations. Results of the regional and site-specific investigations must be considered in application of the probabilistic method. Two current probabilistic methods are the NRC- sponsored study conducted by Lawrence Livermore National Laboratory and the Electric Power Research Institute's seismic hazard study. These are regional studies without detailed information on any specific location. The regional and site-specific investigations provide detailed information to update the database of the hazard methodology to make the probabilistic analysis site-specific.

Applicants also must incorporate local site geological factors such as stratigraphy and topography and account for site-specific geotechnical properties in establishing the DE. In order to incorporate local site factors and advances in ground motion attenuation models, ground motion estimates are determined using the procedures outlined in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Reactors", Section 2.5.2, "Vibratory Ground Motion."

(2) The second change would allow applicants to use a DE appropriate for and commensurate with the risk associated with an ISFSI.

The present DE for ISFSIs is based on the requirements contained in 10 CFR Part 100 for NPPs. In the Statement of Consideration accompanying the initial Part 72 rulemaking, the Commission recognized that the design peak horizontal acceleration for SSCs need not be as high as for a nuclear power reactor, and should be determined on a "case-by-case" basis until more experience is gained with licensing of these types of units (45 FR 74697). With over 10 years of experience licensing dry cask storage, and analyses demonstrating robust behavior of dry cask storage systems (DCSSs) in accident scenarios, the Commission now has a reasonable basis to consider lower and more appropriate DE parameters for dry cask ISFSIs.

The present ISFSI DE (equivalent to the SSE for a NPP) has a mean annual probability of exceedance of approximately 1.0E-04 (i.e., in any one year, the probability is one in ten thousand that the DE established for the site will be exceeded). In comparison with a nuclear power plant, an operating ISFSI is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI does not have the variety and complexity of active systems necessary to support an operating NPP. Further, the robust cask design required for non-seismic considerations (e.g., drop event, shielding), assure low probabilities of failure from seismic events.

In the unlikely occurrence of a radiological release as a result of a seismic event, the radiological consequences to workers and the public are significantly lower than those that could arise at a NPP. This is because the conditions required for release and dispersal of significant quantities of radioactive material, such as high temperatures or pressures, are not present in an ISFSI. This is primarily due to the low heat-generation rate of spent fuel that has undergone more than one year of decay before storage in an ISFSI, and to the low inventory of volatile radioactive materials readily available for release to the environment. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. Short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel. Furthermore, even if the short-lived nuclides were present during a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the Commission believes that the seismically induced radiological risk associated with an ISFSI is less than the risk associated with a NPP and the use of a lower DE is appropriate.

Additional rationale supporting the Commission's proposal to reduce the DE is provided below.

- The critical element for protection against radiation release is the steel cask containing the spent fuel assemblies. The standards in Part 72 Subparts E - Siting Evaluation Factors and F - General Design Criteria, ensure that the dry storage cask designs are very rugged and robust, and are expected to have substantial design margins to withstand forces from a seismic event greater than the DE.

- During a seismic event at an ISFSI, a cask may slide if lateral seismic forces are greater than the frictional resistance between the cask and the concrete pad. The sliding and resulting displacements are computed by the applicant to demonstrate that the casks, which are spaced to satisfy the thermal criteria in Part 72 Subpart F, are precluded from impacting other adjacent casks. Furthermore, the NRC staff guidance in reviewing cask designs is to show that casks are designed to prevent sliding or tip over during a seismic event. However, even if the casks slide or tip over and then impact other casks or the pad during a seismic event significantly greater than the proposed DE, there are adequate design margins to ensure that the casks maintain their structural integrity.

- Because the DE is a smooth broad-band spectrum, which envelops the controlling earthquake responses, the vibratory ground motion specified is conservative.

- The combined probability of the occurrence of a seismic event and operational failure that leads to a radiological release is much smaller than the individual probabilities of either of these events. This is because the handling building and crane are used for only a fraction of the licensed period of an ISFSI and for only a few casks at a time. Therefore, the risk of a potential release of radioactivity due to failure of the cask handling building and/or crane during a seismic event is small.

- The crane used for lifting the casks in the building is designed using the same industry codes as for a nuclear power plant (ACI 349, AISC N690, ANSI N14.6, and NUREG-0612), and has a safety factor of five (5) or greater for lifted loads using the ultimate strength of the materials. Therefore, the crane would perform satisfactorily for an earthquake ground motion much larger than the DE.

- The determination of a DE for ISFSIs is consistent with the design approach used in DOE Standard DOE-STD-1020, "Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities," for similar type facilities.

(3) The third change would require that the design of cask storage pads and areas at ISFSIs adequately account for dynamic loads in addition to static loads.

The Commission is proposing a change to clarify that 10 CFR Part 72 general licensees must perform both static and dynamic loads for new ISFSIs after the effective date of the rule to ensure that casks are not placed in an unanalyzed condition. The change would state that the design of cask storage pads and areas must adequately account for dynamic loads (in addition to static loads). For example, dynamic effects can cause soil-structure interactions that could amplify ground motion to the point that the acceleration on the casks is greater than the DE acceleration, or soil liquefaction could cause unacceptable pad and foundation settlement. Accounting for dynamic loads in the analysis of ISFSI pads and areas would ensure that the pad continues to support the casks during seismic events.

3.0 Proposed Action and Alternatives

The options (alternatives) under consideration are:

Option 1. No Action. The siting requirements for new dry casks ISFSIs would continue to conform to the existing requirements of § 72.102.

Option 2. Require new Part 72 specific license applicants to conform to § 100.23 in lieu of Appendix A to Part 100.

Option 3. Require new Part 72 specific license applicants to conform to § 100.23 in lieu of Appendix A to Part 100, and also give them the option to use a graded approach to seismic design of the ISFSI SSCs.

Option 4. (1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

(2) Maintain the present Part 72 requirement of using a single-level DE, but with a lower DE that is commensurate with the level of risk associated with an ISFSI. Draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications.

Option 4 is the only option that considers whether a site is located with a NPP in determining applicability of the proposed requirements (see Table 3-1 below). Options 2 and 3 do not make this distinction.

Table 3-1. Summary of Applicability

DE for ISFSI or MRS Specific License Applicants for Dry Cask Modes of Storage on or after the Effective Date of the Final Rule	
Site Condition	Specific License[1]
Western U.S., or areas of known seismic activity in the eastern U.S., **not** co-located with NPP	Must use PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2]
Western U.S., or areas of known seismic activity in the eastern U.S., **and** co-located with NPP	PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2], **or** existing NPP design criteria (multi-unit sites - use the most recent criteria)
Eastern U.S., and not in areas of known seismic activity	PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2], **or** existing NPP design criteria, if applicable (multi-unit sites - use the most recent criteria), **or** an appropriate response spectrum anchored at 0.25g (subject to the conditions in proposed § 72.103(a)(1)).

1. Proposed § 72.103 does not apply to general licensees. General licensees must satisfy the conditions given in 10 CFR 72.212.
2. Regardless of the results of the investigations, anywhere in the continental U.S., the DE must have a value for the horizontal ground motion of no less than 0.10 g with the appropriate response spectrum.

Additional Change

The Commission is also proposing a change to § 72.212(b)(2)(i)(B) to require that general licensees evaluate dynamic loads (in addition to static loads) in the design of cask storage pads and areas. This proposed change is an additional modification, separate from the changes proposed in the options above.

NRC would change § 72.212(b)(2)(i)(B) to require written evaluations, prior to use, establishing that cask storage pads and areas have been evaluated for the static and dynamic loads of the stored casks.

3.1 Comparison of Proposed Options

This section compares the requirements of the proposed options. These options differ with regard to seismological and geological siting criteria and estimation of the DE for ISFSIs, and whether single-level DEs will be used in evaluating the design of ISFSI SSCs. As noted above, requirements for consideration of dynamic loads in the design of cask storage pads and areas may be promulgated along with any option. A summary of the requirements of the proposed options is provided in Table 3-2.

Table 3-2. Comparison of Requirements Under Proposed Options

Option	Seismic Siting Criteria, DE Definition	DE for Systems, Structures, and Components (SSCs)
1. (No Action)	Current § 72.102. Sites in the western U.S. do seismic analysis as required by Appendix A to Part 100. In the eastern U.S., use Appendix A analysis or DE with response spectrum anchored at 0.25g ground motion. If Appendix A is used at any site, DE is defined as the SSE for a NPP.	Current § 72.102.
2	Applicant must conform to § 100.23, requiring PSHA or suitable sensitivity analyses in lieu of Appendix A to Part 100, or other options compatible with the existing regulation.	Current § 72.102.
3	Applicant must conform to § 100.23, requiring PSHA or suitable sensitivity analyses in lieu of Appendix A to Part 100, or other options compatible with the existing regulation.	Require applicants to use graded approach to seismic design of SSCs. Similar to Parts 60 and 63; Category 1 event annual probability = 1.0E-03, Category 2 event annual probability = 1.0E-04.
4	Applicant must comply with new § 72.103 requiring use of PSHA or suitable sensitivity analyses in lieu of Appendix A to Part 100, or other options compatible with the existing regulation.	Single level DE for SSCs or other options compatible with the existing regulation.

3.1.1 Option 1: No-Action Alternative

Under Option 1, new specific license applicants for dry cask ISFSIs would continue to meet the existing requirements of 10 CFR 72.102. As noted in section 1, currently, ISFSI applicants at sites located in either the western U.S. or in the eastern U.S. in areas of known seismic activity must currently perform deterministic site seismic evaluations as prescribed in Appendix A to Part 100. ISFSIs located in the eastern U.S. and not in areas of known seismic activity may use a standardized design earthquake (peak ground acceleration of 0.25g) if justified by sufficient geological investigations and literature review. For any application in which the methods in Appendix A are used, the DE for the ISFSI must be no less than the SSE for a NPP.

As noted in the previous sections, the current requirements may result in more costly designs, are deterministic, and employ outdated criteria developed for power reactors, to define siting criteria for the much less complex and hazardous ISFSIs. Therefore, this approach does not consider uncertainties in the seismic hazard assessment, is not risk-informed, and may not be cost effective.

3.1.2 Option 2: Require New Part 72 Specific License Applicants to Conform to § 100.23 in lieu of Appendix A to Part 100

This option would require certain specific license applicants to address uncertainties in seismic hazard analysis by using a PSHA or suitable sensitivity analyses for determining the DE, as described in §§ 72.103 and 100.23. This would bring the seismic site evaluation requirements for ISFSIs into conformance with the updated requirements for NPPs. By accepting the use of a PSHA methodology or suitable sensitivity analyses in § 100.23, the Commission has recognized that the uncertainties in seismological and geological information must be formally evaluated and appropriately accommodated in the determination of the SSE for seismic design of NPPs. The Commission, in promulgating § 100.23 further recognized that the nature of uncertainty and the appropriate approach to account for it depends on the tectonic environment of the site and on properly characterizing parameters input to the PSHA or suitable sensitivity analyses such as seismic sources, the recurrence of earthquakes within a seismic source, the maximum magnitude of earthquakes within a seismic source, and engineering estimation of earthquake ground motion.

The Commission notes that while strict adherence to the requirements in Appendix A for determining the DE for the ISFSI (equivalent to a NPP SSE) will be removed, those applicants for ISFSIs, co-located with existing nuclear power plant sites, would be allowed to use all of the geophysical investigation information obtained from the original licensing process (which used the Appendix A requirements), in verifying that all applicable seismic data are considered in determining the design basis. The benefit of this option is that it would be a conforming change to Part 100 for evaluating geological and seismological criteria. It should be noted that under this option, the extent of site investigations and characterization remains the same as required in Part 100. Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," was developed to provide general guidance on procedures acceptable to the staff for satisfying the requirements of § 100.23 for NPPs. This guidance would be considered acceptable for ISFSIs.

This option retains the § 72.102(f)(1) requirement that the DE for ISFSIs be equivalent to the SSE for a NPP. Thus, while improving the technical requirements for site seismic analysis, this option is still not risk-informed, in that the same DEs are defined for the much less hazardous ISFSIs as for NPPs.

3.1.3. Option 3:

(1) Require New Part 72 Specific License Applicants to Conform to § 100.23 in lieu of Appendix A to Part 100

(2) Provide new Part 72 applicants the option to use a graded approach to seismic design for ISFSI SSCs.

This option is the same as Option 2, except that it would require applicants to use a graded approach to developing seismic design criteria for SSCs. The specific approach proposed for dry cask ISFSIs would be comparable to the Parts 60 and 63 graded approach to design ground motion for SSCs of pre-closure facilities (§ 60.2). In general, a graded approach to design requires those SSCs whose failure would result in greater accident consequences to use higher design requirements for phenomena such as earthquakes and tornadoes (Category 2 event). Similarly, those SSCs whose failure would result in lesser accident consequences would be designed to less stringent requirements (Category 1 event). For seismic events, the Commission has accepted the approach described in DOE Topical Report YMP/TR-003-NP, Rev. 2, Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain, pertaining to Part 63. In this approach Category 1 design basis ground motion refers to a mean annual probability of exceedance of 1.0E-03. Category 2 design basis ground motion refers to a mean annual probability of exceedance of 1.0E-04.

Individual SSCs that are required to maintain the annual dose within the regulatory limits of 10 CFR Part 20 would be designed to a Category 1 design earthquake. Other SSCs needed to be functional to prevent the dose limit of 5 rem from being exceeded at the controlled area boundary due to a seismic event, would be designed to a Category 2 design earthquake. Thus, the seismic design of the SSCs would be commensurate with their importance to safety.
By requiring uncertainties in seismic hazard analysis to be addressed using a PSHA or suitable sensitivity analyses to define the DE for ISFSIs, and the use of a graded approach to defining seismic criteria for SSCs, Option 3 sets siting and design criteria that are much more risk-informed than Options 1 and 2, and are more flexible than the proposed requirements in Option 2. It would, however, be more complex to implement than Option 2 and, as discussed in Section 4, would not achieve a meaningful risk reduction compared to the approach defined in Option 4.

3.1.4 Option 4:

(1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

(2) Maintain the present Part 72 requirement of using a single-level DE, but with a lower DE that is commensurate with the level of risk associated with an ISFSI. The draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level of an SSE for a NPP, for ISFSI applications.

Option 4 would require that:

(1) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a NPP, would be required to address uncertainties in seismic hazard analysis by using a PSHA or suitable sensitivity analyses, for determining the DE;

(2) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in either the western U.S. or in areas of known seismic activity in eastern U.S., and co-located with a NPP, would have the option of using a PSHA methodology or suitable sensitivity analyses for addressing uncertainties in seismic hazard analysis in determining the DE, or using the existing design criteria for the NPP. When the existing design criteria for the NPP are used for an ISFSI at a site with multiple NPPs, the criteria for the most recent NPP must be used;

(3) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in eastern U.S., except in areas of known seismic activity, would have the option of using a PSHA methodology or suitable sensitivity analyses for addressing uncertainties in seismic hazard analysis in determining the DE, or using the standardized DE described by an appropriate response spectrum anchored at 0.25 g (subject to the conditions in proposed § 72.103(a)(1)), or using the existing design criteria for the most recent NPP (if applicable); and

(4) The proposed changes regarding the use of a PSHA methodology or suitable sensitivity analyses for addressing uncertainties in seismic hazard analysis in determining the DE are not applicable to a general licensee at an existing NPP operating an ISFSI under a Part 72 general license anywhere in the U.S.

Option 4 would also maintain the present Part 72 requirement of using a single DE for defining ISFSI SSC seismic design criteria, but with a lower ground motion that is commensurate with the level of risk associated with ISFSIs. The draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications. Seismic design criteria for Part 72, when originally issued in 1980, were based on the nuclear plant requirements, and require a DE with a mean annual probability of exceedance of approximately 1.0E-04. Part 72 regulations classify ISFSI facility systems, structures, and components (SSCs) based on their importance to safety. SSCs, whose function is to protect the public health and safety from undue risk, and prevent damage to the spent fuel during handling and storage, are classified as important to safety. These SSCs are evaluated for a single level of DE as an accident condition event only (§ 72.106). For normal operations and anticipated occurrences (§ 72.104), earthquake events are not included.

In the Statements of Consideration accompanying the initial Part 72 Rulemaking, the Commission recognized that the design peak horizontal acceleration for SSCs need not be as high as for a nuclear power reactor, and should be determined on a "case-by-case" basis until "more experience is gained with licensing of these types of units." With over 10 years of experience licensing dry cask storage, and analyses demonstrating robust behavior of DCSSs in accident scenarios, NRC staff now have a reasonable basis to consider a different design value that is adequate for licensing dry cask storage ISFSIs.

The DCSSs for ISFSI applications are typically self-contained massive concrete or steel structures, weighing approximately 40 to 100 tons when fully loaded. There are very few, if any, moving parts. They are set on a concrete support pad. Several limitations have been set on the maximum height to which the casks can be lifted, based on the drop accident analysis. There is a minimum center-to-center spacing requirement for casks stored in an array on a common support pad. The most conservative estimates of structural thresholds of seismic inertia deceleration due to a drop accident event, before the confinement is breached so as to exceed the permissible radiation levels, is in the range of 30 g to 40 g.

3.2 Dynamic Loads and Soil Stability

Changes to § 72.212(b)(2)(i)(B) are also needed to communicate that general licensees must evaluate both static and dynamic loads for designing new ISFSIs after the effective date of the rule to ensure that casks are not placed in an unanalyzed condition. The change would state that the design of cask storage pads and areas must adequately account for dynamic loads (in addition to static loads). For example, dynamic effects can cause soil-structure interactions that could amplify ground motion to the point that the acceleration on the casks is greater than the design earthquake acceleration, or that soil liquefaction could cause unacceptable pad and foundation settlement. Evaluation of dynamic loads for cask pads and areas would ensure that the pad, which may be considered as failed in a seismic event, could continue to support the casks without placing them in an unanalyzed condition.

4.0 Environmental Consequences

Overall, no adverse environmental impacts will result from any of the options identified. Dry storage casks used at ISFSI's are passive systems with natural cooling sufficient to maintain safe temperatures and a robustness or structural integrity to withstand external forces. The cask walls provide adequate shielding and no radioactive products are released under normal and credible conditions. Other systems, structures, and components would also be designed to standards affording a high degree of environmental protection under normal and credible conditions.

4.1 Environmental Consequences of Option 1: No-Action

The no-action alternative would not result in any change to current seismic design criteria, nor would it affect the DE definition for ISFSI SSCs. No environmental impacts are expected under the current regulation. This conclusion is based on the finding of no significant impact prepared for the previous Part 72 rulemaking (45 FR 74693, November 12, 1980) and NRC's years of experience with licensing ISFSIs.

4.2 Environmental Consequences of Option 2: Require New Part 72 Specific License Applicants to Conform to § 100.23 in lieu of Appendix A to Part 100

No adverse environmental impacts are expected under Option 2. Under this option, certain specific license applicants would be required to address uncertainties in seismic hazard analysis by using a PSHA or suitable sensitivity analyses in determining the DE for ISFSIs. This option would require the same site investigation and characterization as under current rules, and would retain the requirement that the DE for the ISFSI be at least as stringent as the SSE for a NPP. The use of a PSHA or suitable sensitivity analyses for addressing uncertainties in seismic hazard analysis for determining the DE for ISFSIs would be more risk-informed than the deterministic approach. Under this option, all ISFSIs would still meet the radiological protections standards in 10 CFR 72.104(a) and 72.106(b), and thus the degree of protection of the environment and public health is maintained.

4.3 Environmental Consequences of Option 3:

(1) Require New Part 72 Specific License Applicants to Conform to § 100.23 in lieu of Appendix A to Part 100

(2) Provide new Part 72 applicants the option to use a graded approach to seismic design for ISFSI SSCs.

No adverse environmental impacts are expected under Option 3. As under Option 2, use of a PSHA or suitable sensitivity analyses to address uncertainties in seismic hazard analysis for determining the DE for an ISFSI would be protective. Under the graded approach to developing design criteria for ISFSIs, the DE for SSCs important to safety would still be the SSE for a NPP. For these SSCs, there is therefore no change in risk of radiological exposure. SSCs could be designed to withstand Frequency Category 1 events (the less stringent criteria) only if the applicant's analysis provides reasonable assurance that the failure of the SSC would not cause the facility to exceed the radiological protection requirements of § 72.104(a) under normal operations. If the specific license applicant's analysis cannot support this conclusion, the SSC would have to be designed such that the facility can withstand Frequency Category 2 events without impairing the ISFSI's capability to perform safety functions and not exceed the radiological protection requirements of § 72.106(b). Thus, no additional risk to the environment and public would be incurred.

4.4 Environmental Consequences of Option 4:

(1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

(2) Maintain the present Part 72 requirement of using a single-level DE, but with a lower DE that is commensurate with the level of risk associated with an ISFSI. The draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications.

This option is similar to Options 2 and 3 in that it requires certain specific license applicants to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. Thus, there would be no adverse effect associated with that aspect of this option. Option 4 also maintains the current single design event for ISFSI SSCs, however, specific licensees would not be required to design any SSCs to withstand a DE as high as the SSE of a NPP. The draft regulatory guide accompanying this proposed rule recommends a DE with a mean annual probability of exceedance of 5.0E-04, for ISFSI applications. NRC staff believe that the use of the less severe design event for all SSCs provides an adequate level of protection from adverse environmental consequences. The general rationale for this finding includes the following considerations:

The present DE (equivalent to the SSE for a NPP) has a mean annual probability of exceedance of approximately 1.0E-04. In comparison with a nuclear power plant, an operating ISFSI is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI does not have the variety and complexity of active systems necessary to support an operating

NPP. Further, the robust cask design required for non-seismic considerations (e.g., drop event, shielding), assure low probabilities of failure from seismic events.

In the unlikely occurrence of a radiological release as a result of a seismic event, the radiological consequences to workers and the public are significantly lower than those that could arise at a NPP. This is because the conditions required for release and dispersal of significant quantities of radioactive material, such as high temperatures or pressures, are not present in an ISFSI. This is primarily due to the low heat-generation rate of spent fuel that has undergone more than one year of decay before storage in an ISFSI, and to the low inventory of volatile radioactive materials readily available for release to the environment. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. Short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel. Furthermore, even if the short-lived nuclides were present during a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the Commission believes that the seismically induced radiological risk associated with an ISFSI is less than the risk associated with a NPP and the use of a lower DE is appropriate.

The Commission indicated in the Statement of Considerations accompanying the initial Part 72 rulemaking that "[f]or ISFSI's which do not involve massive structures, such as dry storage casks and canisters, the required DE will be determined on a case-by-case basis until more experience is gained with the licensing of these types of units." [45 FR 74697 (1980)]. With more than 10 years of experience licensing dry cask storage systems, together with analyses demonstrating their robust behavior in accident scenarios involving earthquakes, the NRC staff concludes that designing ISFSI SSCs using a single-level DE that is commensurate with the level of risk associated with an ISFSI, is sufficient to provide reasonable assurance in demonstrating public health and safety.

The NRC staff's findings with regard to protectiveness include:

- The critical element for protection against radiation release is the sealed cask containing the spent fuel assemblies. The standards in Part 72 Subparts E - Siting Evaluation Factors and F - General Design Criteria, ensure that the dry storage cask designs are very rugged and robust, and are expected to have substantial design margins to withstand forces from a seismic event greater than the DE.

- During a seismic event at an ISFSI, a cask may slide if lateral seismic forces are greater than the frictional resistance between the cask and the concrete pad. The sliding and resulting displacements are computed by the applicant to demonstrate that the casks, which are spaced to satisfy the thermal criteria in Part 72 Subpart F, are precluded from impacting other adjacent casks. Furthermore, the NRC staff guidance in reviewing cask designs is to show that casks are designed to prevent sliding or tip over during a seismic event. However, even if the casks slide or tip over and then impact other casks or the pad during a seismic event significantly greater than the proposed DE, analyses have shown that there are adequate design margins to ensure that the casks maintain their structural integrity.

- Because the DE is a smooth broad-band spectrum, which envelops the controlling earthquake responses, the vibratory ground motion specified is conservative.

- The combined probability of the occurrence of a seismic event and operational failure that leads to a radiological release is much smaller than the individual probabilities of either of these events. This is because the handling building and crane are used for only a fraction of the licensed period of an ISFSI and for only a few casks at a time. Therefore, the risk of a potential release of radioactivity due to failure of the cask handling building and/or crane during a seismic event is small.

- The crane used for lifting the casks in the building is designed using the same industry codes as for a nuclear power plant (ACI 349, AISC N690, ANSI N14.6, and NUREG-0612), and has a safety factor of five (5) or greater for lifted loads using the ultimate strength of the materials. Therefore, the crane would perform satisfactorily for an earthquake much larger than the DE.

- The determination of a DE for ISFSIs is consistent with the design approach used in DOE Standard DOE-STD-1020, "Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities," for similar type facilities.

In addition, none of the proposed changes will significantly affect the construction or operation of an ISFSI facility and therefore, there is no increased risk to the environment associated with this option.

4.5 Environmental Consequences of Considering Dynamic Loads

NRC would change § 72.212(b)(2)(i)(B) to require written evaluations, prior to use, establishing that cask storage pads and areas have been evaluated for the static and dynamic loads of the stored casks. No adverse environmental impacts are expected to result from the proposed change to evaluate dynamic as well as static loads in the design of ISFSI storage pads and areas. The proposed changes are intended to require that general licensees perform appropriate analyses to ensure that the seismic design bases for the casks are met and that casks are not placed in an unanalyzed condition. Therefore, these proposed changes are necessary to assure adequate protection to occupational and public health and safety. The proposed changes to § 72.212 would not actually impose new burden on the general licensees because they currently need to consider dynamic loads to meet the requirements in § 72.212(b)(2)(i)(A). Since the general licensees currently evaluate dynamic loads for evaluating the cask pads and areas, the proposed changes to § 72.212(b)(2)(i)(B) would not actually require any present general licensees operating an ISFSI to re-perform any written evaluations previously undertaken.

4.6 Summary

The purpose of the options under consideration is to enable ISFSI applicants to incorporate state-of-the-art improvements in the geosciences and engineering and require a risk-informed regulation, while maintaining protection against radiological risks. As discussed in sections 3 and 4, NRC staff has concluded that neither the options to use a PSHA or suitable sensitivity analyses to address uncertainties in seismic hazard analysis for determining the DE for ISFSIs, nor the recommendation to reduce the mean annual probability of exceedance for the DE will adversely affect the safety of ISFSI designs. Dry storage casks used at an ISFSI are passive systems with natural cooling sufficient to maintain safe temperatures and a robustness or structural integrity to withstand external forces. The cask walls provide adequate shielding and no radioactive products are released under any credible accident conditions. Other SSCs will also be designed to standards affording a high degree of environmental protection under normal operations and credible accident conditions. In addition, none of the proposed changes will significantly affect the construction or operation of an ISFSI facility.

Under all the options under consideration, ISFSIs will still be able to meet the radiological protection standards of §§72.104(a) and 106(b). Thus, there will be no adverse environmental impacts from the proposed rule changes, no matter which option is chosen.

5.0 Finding of No Significant Impact

Based on the foregoing draft environmental assessment, the Commission has determined under the National Environmental Policy Act of 1969, as amended, and the Commission's regulations in Subpart A of 10 CFR Part 51, not to prepare an environmental impact statement for this proposed rule because the Commission has concluded, based on an Environmental Assessment, that this proposed rule, if adopted, would not be a major Federal action significantly affecting the quality of the human environment.

The Commission concluded that no significant environmental impact would result from this rulemaking. In comparison with a NPP, an operating ISFSI or MRS is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI or MRS does not have the variety and complexity of active systems necessary to support an operating NPP. Once the spent fuel is in place, an ISFSI or MRS is essentially a static operation and, during normal operations, the conditions required for the release and dispersal of significant quantities of radioactive materials are not present. There are no high temperatures or pressures present during normal operations or under design basis accident conditions to cause the release and dispersal of radioactive materials. This is primarily due to the low heat generation rate of spent fuel after it has decayed for more than one year before storage in an ISFSI or MRS and the low inventory of volatile radioactive materials readily available for release to the environs. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. The short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel stored at an ISFSI or MRS. Furthermore, even if the short-lived nuclides were present during an event of a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the seismically induced radiological risk associated with an ISFSI or MRS is less than the risk associated with a NPP.

The determination of this environmental assessment is that there will be no significant environmental impact due to the proposed changes because the same level of safety would be maintained by the new requirements, taking into account the lesser risk from an ISFSI or MRS. However, the general public should note that the NRC welcomes public participation. Comments on any aspect of the Environmental Assessment may be submitted to: Secretary, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, Attention: Rulemaking and Adjudications Staff.

Deliver comments to 11555 Rockville Pike, Rockville, Maryland, between 7:30 a.m. and 4:15 p.m. on Federal workdays.

You may also provide electronic comments via the NRC's interactive rulemaking website at (http://ruleforum.llnl.gov). This site provides the capability to upload comments as files (any format), if your web browser supports that function. For information about the interactive rulemaking website, contact Ms. Carol Gallagher at (301) 415-5905, or e-mail cag@nrc.gov.

The NRC has sent a copy of the Environmental Assessment and this proposed rule to every State Liaison Officer and requested their comments on the Environmental Assessment. The Environmental Assessment may be examined at the NRC Public Document Room, O-1F21,11555 Rockville Pike, Rockville, MD. Single copies of the Environmental Assessment are available from Keith K. McDaniel, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555-0001, telephone: (301) 415-5252, e-mail: kkm@nrc.gov.

6.0 Agencies and Persons Consulted

No other agencies or persons were consulted in the preparation of this draft environmental assessment.

Note: State regulatory agencies and members of the public will have an opportunity to comment on the draft EA when it is published in the *Federal Register*.